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14. ABSTRACT
We have investigated a highly robust scheme for the pulse compression of femtosecond pulses in gases in which the optimal compression consists of a distinct sequential two plasma-filament structure. By matching experimental trends between linear and circular polarizations propagating through argon, krypton, and xenon with numerical simulations of the complex spatiotemporal dynamics, we gather new insight into effects of how generated plasma interacts with the propagating pulse field. More specifically, we describe the role of balancing plasma inverse bremsstrahlung scattering with multiphoton ionization rates for pulse compression schemes. In addition, we have studied the collapse dynamics of several spatially separated in-phase Gaussian beams in bulk Kerr media, where each beam has a power P which is slightly above Pcr the critical power for collapse. We find that complex fusion or annihilation behavior can occur depending on the initial configuration of the beams. Our results shed light on the basic interaction between self focused beams and may provide a mechanism to control the collapse dynamics of such beams.

15. SUBJECT TERMS
photonic band-gap fibers, filimentation control, pulse compression, femtosecond laser pulses

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I) Scientific Personnel: Two PhD candidates (Amar Bhagwat, Chris Hensley) and one post doc (Pablo Londero) at different times were supported during this period.

II) List of Manuscripts:

1. L. T. Vuong, R. B. Lopez-Martens, C. P. Hauri, and A. L. Gaeta,□ "Spectral reshaping and pulse compression via sequential filamentation in gases," □*Opt. Express* **16**, 390 (2008).
2. A. A. Ishaaya, L. T. Vuong, T. D. Grow, and A. L. Gaeta,□ "Self-focusing dynamics of polarization vortices in Kerr media," □*Opt. Lett.* **33**, 13 (2008).
3. C. J. Hensley, D. H. Broaddus, A. L. Gaeta, and C. B. Schaffer, "Photonic band-gap fiber gas cell fabricated using femtosecond micromachining," *Opt. Express* **15**, 6690 (2007).

III) Conference presentations (Invited):

1) L.T. Vuong, A.A. Ishaaya, and A.L. Gaeta, "Nonlinear interactions between optical vortex beams," delivered at the Laser Physics Workshop, Leon, Mexico in August (2007).
2) L.T. Vuong, A.A. Ishaaya, T.D. Grow, A.L. Gaeta, E.R. Eliel, and Gert 't Hooft, "Experiments showing orbital angular momentum exchange between optical vortex beams," delivered at the International Quantum Electronics Conference, Munich, Germany in June (2007).
3) A. L. Gaeta, "Interaction of light with atoms and molecules in photonic band-gap fibers," delivered at the Ninth Rochester Conference on Coherence and Quantum Optics in Rochester, NY in June 2007.
4) A. A. Ishaaya, T. D. Grow, L. T. Vuong and A. L. Gaeta, "Spatial collapse dynamics in self-focusing Kerr media," delivered at the International Conference on Coherent and Nonlinear Optics (ICONO 2007), Minsk, Belarus in May (2007).
5) A. L. Gaeta, "Interaction of light with atoms and molecules in photonic band-gap fibers," delivered at the 2007 Cross-Border Workshop in Toronto, Ontario in May 2007.

II) Inventions: none

IV) Scientific Progress and Accomplishments

During this funding period, we have achieved significant results in two main areas:

1) Filamentation with high-power femtosecond laser pulses
2) Coherent nonlinear interactions with atoms and molecules in photonic band-gap fibers.

1) Filamentation of high-power femtsecond laser pulses

We investigated a highly robust scheme for the pulse compression of femtosecond pulses in gases in which the optimal compression consists of a distinct sequential two plasma-filament structure. By matching experimental trends between linear and circular polarizations propagating through argon, krypton, and xenon with numerical simulations of the complex spatiotemporal dynamics, we gather new insight into effects of how generated plasma interacts with the propagating pulse field. More specifically, we describe the role of balancing plasma inverse bremsstrahlung scattering with multiphoton ionization rates for pulse compression schemes. In addition, we have studied the collapse dynamics of several spatially separated in-phase Gaussian

beams in bulk Kerr media, where each beam has a power P which is slightly above P_{cr} the critical power for collapse. We find that complex fusion or annihilation behavior can occur depending on the initial configuration of the beams. Our results shed light on the basic interaction between self focused beams and may provide a mechanism to control the collapse dynamics of such beams.

2) Coherent Interactions with Rb Atoms in photonic band-gap fibers

We have continued our experiments on nonlinear interactions with gases in hollow-core photonic band-gap fibers. We fabricated a high-transmission, variable-pressure gas fiber cell that can operate at low and high pressures, which is formed by using femtosecond pulses to drill micrometer-diameter radial capillaries through a hollow-core photonic band-gap fiber. In addition, we have had success in generating appreciable densities of Rb atoms within the fiber core. We show that by using desorption pulses of the suitable power and duration, we can generate on-demand and highly controlled optical densities of Rb vapor inside the core. Our technique allows for repeated experiments under near-identical experimental conditions over relatively short time scales which greatly enhances our ability to obtain data. We have also used this technique to perform time-resolved study of the rich physics of atomic desorption inside these coated fibers.